

LARGE-SCALE VOLCANISM ASSOCIATED WITH CORONAE ON VENUS; K. Magee Roberts and J. W. Head, Department of Geological Sciences, Brown University, Providence, RI 02912

The formation and evolution of coronae on Venus are thought to be the result of mantle upwellings against the crust and lithosphere and subsequent gravitational relaxation.¹⁻⁶ A variety of other features on Venus have been linked to processes associated with mantle upwelling, including shield volcanoes on large regional rises such as Beta, Atla and Western Eistla Regiones⁷ and extensive flow fields such as Mylitta and Kaiwan Fluctus near the Lada Terra/Lavinia Planitia boundary.⁸ Of these features, coronae appear to possess the smallest amounts of associated volcanism, although volcanism associated with coronae has only been qualitatively examined. An initial survey of coronae based on recent Magellan data indicated that only 9% of all coronae are associated with substantial amounts of volcanism, including interior calderas or edifices greater than 50 km in diameter and extensive, exterior radial flow fields.⁴ Sixty-eight percent of all coronae were found to have lesser amounts of volcanism, including interior flooding and associated volcanic domes and small shields; the remaining coronae were considered deficient in associated volcanism.⁴ It is possible that coronae are related to mantle plumes or diapirs that are lower in volume or in partial melt than those associated with the large shields or flow fields. Regional tectonics or variations in local crustal and thermal structure may also be significant in determining the amount of volcanism produced from an upwelling. It is also possible that flow fields associated with some coronae are sheet-like in nature and may not be readily identified. If coronae are associated with volcanic flow fields, then they may be a significant contributor to plains formation on Venus, as they number over 300 and are widely distributed across the planet.⁴ As a continuation of our analysis of large-scale volcanism on Venus,^{8,9} we have reexamined the known population of coronae and assessed quantitatively the scale of volcanism associated with them. In particular, we have examined the percentage of coronae associated with volcanic flow fields (i.e., a collection of digitate or sheet-like lava flows extending from the corona interior or annulus), the range in scale of these flow fields, the variations in diameter, structure and stratigraphy of coronae with flow fields, and the global distribution of coronae associated with flow fields.

Considered in this analysis are 323 coronae with full or partial annuli.^{4,10,11} Volcanic features with strictly radial fractures and structures that lack annuli ("novae"^{5,10}) and volcanic edifices with well-developed calderas often resembling coronae are not considered. Of this population, 126 or 39% possess exterior radial flow fields. This is a higher percentage than the 9% reported in the initial survey⁴ and is based on a careful reexamination of the image data and mapping criteria developed during our analyses of extensive flow fields on Venus.^{8,9} Flow field areas range from 1400 km² to 1.5×10^5 km², with an average area of 1.1×10^5 km². For comparison, the average area associated with the "great flow fields"⁹ or fluctus on Venus is 3.7×10^5 km².

The average diameter of coronae associated with flow fields is 339 km; that of coronae without flow fields is 249 km. This difference is statistically significant and suggests that coronae with flow fields are generally larger than those without and may be associated with larger mantle upwellings and volumes of partial melt. There is no correlation between flow field size and coronae diameter (Fig. 1); the largest flow fields are not associated with the largest coronae (and, presumably, the largest upwellings). Other factors such as age and state of preservation, local crustal structure and thermal gradients may also influence the presence of flow fields at coronae.

Coronae have been classified into five different categories based primarily on the morphology of the annulus.⁴ The "concentric" and "asymmetric" classes are the most common, characterizing over 66% of the entire population.⁴ The majority (41%) of coronae with flow fields are in the concentric category, similar to the population of coronae as a whole. In terms of classification, the distribution of coronae with flow fields differs from the general population only in the greater abundance of coronae with radial structural elements (up to 46%). Such features may be due to tectonic uplift⁴⁻⁶ and/or dike emplacement¹² and are consistent with an association of large amounts of volcanism. There is no correlation between corona type and either flow field area or corona diameter.

The bulk of the flow fields (49%) appear to have been emplaced early in coronae evolution, prior to annulus formation. Approximately 40% were emplaced throughout corona evolution (before and after annulus formation) and only 11% appear to post-date annulus formation. This suggests that flow field emplacement is generally related to the initial stage of corona formation, as might be expected by analogy to flood basalt formation on the earth, which is thought to be linked to the early stages of plume impingement against the lithosphere.¹³ Interior flooding generally occurs after the emplacement of extensive radial flow fields.

Coronae are distributed widely, but not randomly, across Venus; they are concentrated near the equator at about 240° east longitude¹⁴ in the Beta-Atla-Themis (BAT) region that is characterized by a major concentration of volcanic features, broad rises and a complex network of rift and deformation zones.¹⁰ A Mercator plot of coronae with and without flow fields (Fig. 2) reveals no significant difference in the distribution of these features. One possible exception is the region including Themis Regio where there is an alignment of coronae with flow fields directly along the deformation zone and another alignment of coronae without flow fields to the SW, away from the

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zone of active rifting. Approximately 58% of coronae with flow fields are associated with zones of extension, including rift zones, coronae chains, and chasmata. This suggests that regional structure has exhibited some control on the formation of flow fields at coronae, although the distribution of the two populations of coronae does not appear to be significantly different.

In summary, volcanism is shown to be associated with a considerably greater number of coronae than found in initial surveys. Flow field volcanism is preferentially associated with larger coronae and in many cases is related to extensional tectonic environments. Volcanism is predominately associated with early stages of corona evolution, although in some cases, late-stage volcanic activity in the central parts of coronae has occurred. We are currently assessing flow lengths, volumes, and distribution to further define the nature and geometry of melting associated with coronae and are developing criteria for distinguishing the relative ages of coronae and associated flow fields to assess any evidence for variations in the preservation of flow fields as a function of time. In addition, we are evaluating the potential contribution volcanism associated with coronae may have on plains formation and reasons for the differences in the scale of volcanism between the range of features on Venus linked to mantle upwelling.

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Figure 1. Corona diameter vs. flow field area

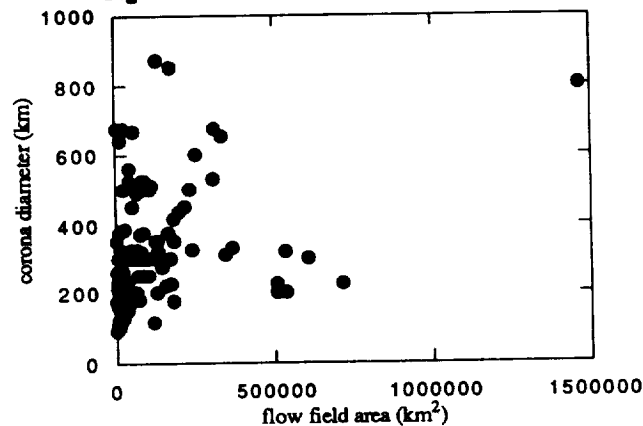


Figure 2. Distribution of coronae with flow fields (x's) and without (triangles)

